Open Architecture Controls: The Key to Interoperability

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Interoperability Costs

- Installed robot systems cost 3 to 5 times the amount of the robot

- Software integration costs are at least 25% of total; much of that cost could be avoided with appropriate standards

- Aerospace manufacturing cell with $10M in capital equipment takes 100 person-years to integrate

Interoperability

- **User's Perspectives:** Seamless data flow, plug & play

  Heterogeneous environment

- **Vendor's Perspectives:** External interfaces

  Market control

- **Third Party Perspectives:** Modular commonality

  Clean interfaces

- **Interfaces exist within an architecture**

NIST Intelligent Open Architecture Controls Program

- GOAL: To provide measurements and standards needed to support a competitive market in intelligent control technology for the discrete parts manufacturing sector.

    - Performance measures

    - Architectures and interface standards

    - Validation and conformance tests

User Groups Are Driving Toward Standardization

- Three key industry segments: machine tools, robotics, measurement equipment
  - Open Modular Architecture Controller (OMAC) for machine tools
  - Robotic Industries Association (RIA) for robotics
  - Metrology Automation Association (MAA) for measurement equipment
- Common theme: bring users and vendors together to work toward standardization

NIST's Roles:
Testing and Validation

- We participate in standards projects, e.g., STEP/NC for machine tool programming, DMIS and AP219 for inspection, AWS A9, and RIA R15

- We set up testbeds to prove out standards

- We develop test suites that enable users and vendors to verify compliance to specifications

- Program information, workshop proceedings, and links to further information can be found at:
  - www.isd.mel.nist.gov/projects/openarch

NIST OAC Testbeds

- Existing
  - Parallel kinematic machine tool
  - Enhanced machine control (NGC, TEAM, OMAC)
  - Welding cell interoperability (with AWS)
- Planned
  - Metrology Automation (with MAA)
  - Single Axis OMAC (with OMAC)
  - STEP/NC (with ISO, Step Tools, OMAC,…)

Open Architecture Controls for Industrial Robots

- 1999 Robotics Industry Forum
- February workshop, Orlando
- June workshop, Ypsilanti
- November workshop (postponed)

Vendor Position

- OMAC Component-based software architecture does not make sense for industrial robots

- Open Architecture for industrial robots means interoperability

Vendor Position

- PC augmented architecture
- External interfaces that are valid subjects for standardization:
  - Factory Data Network interface
  - Peripheral interfaces
  - Graphical Display Interface

Target Interfaces

CAD

OLP/
Simulation

Graphical
Display

Ethernet

Factory Data
Network

PC

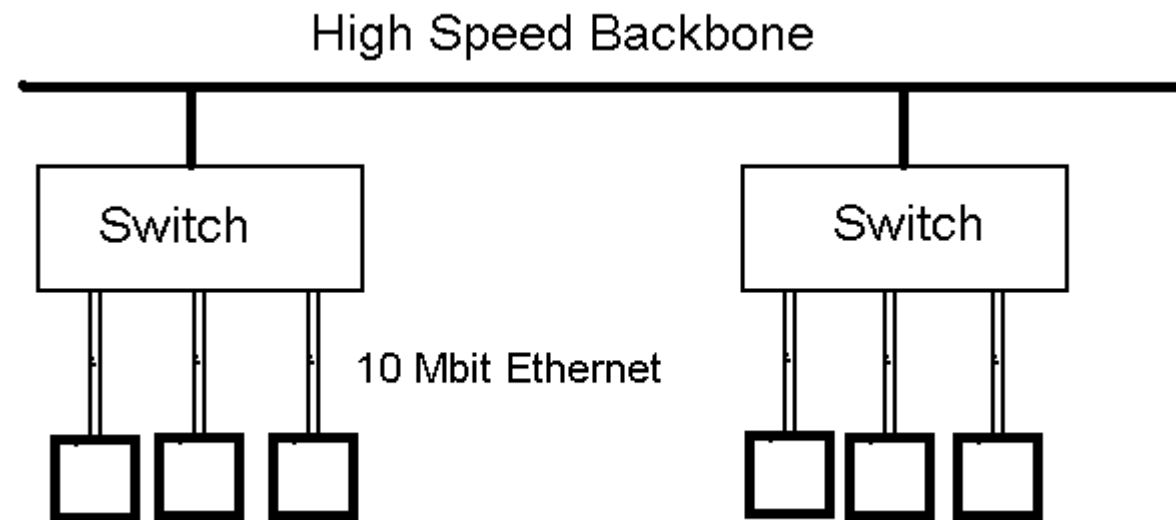Controller

Peripheral
Equipment
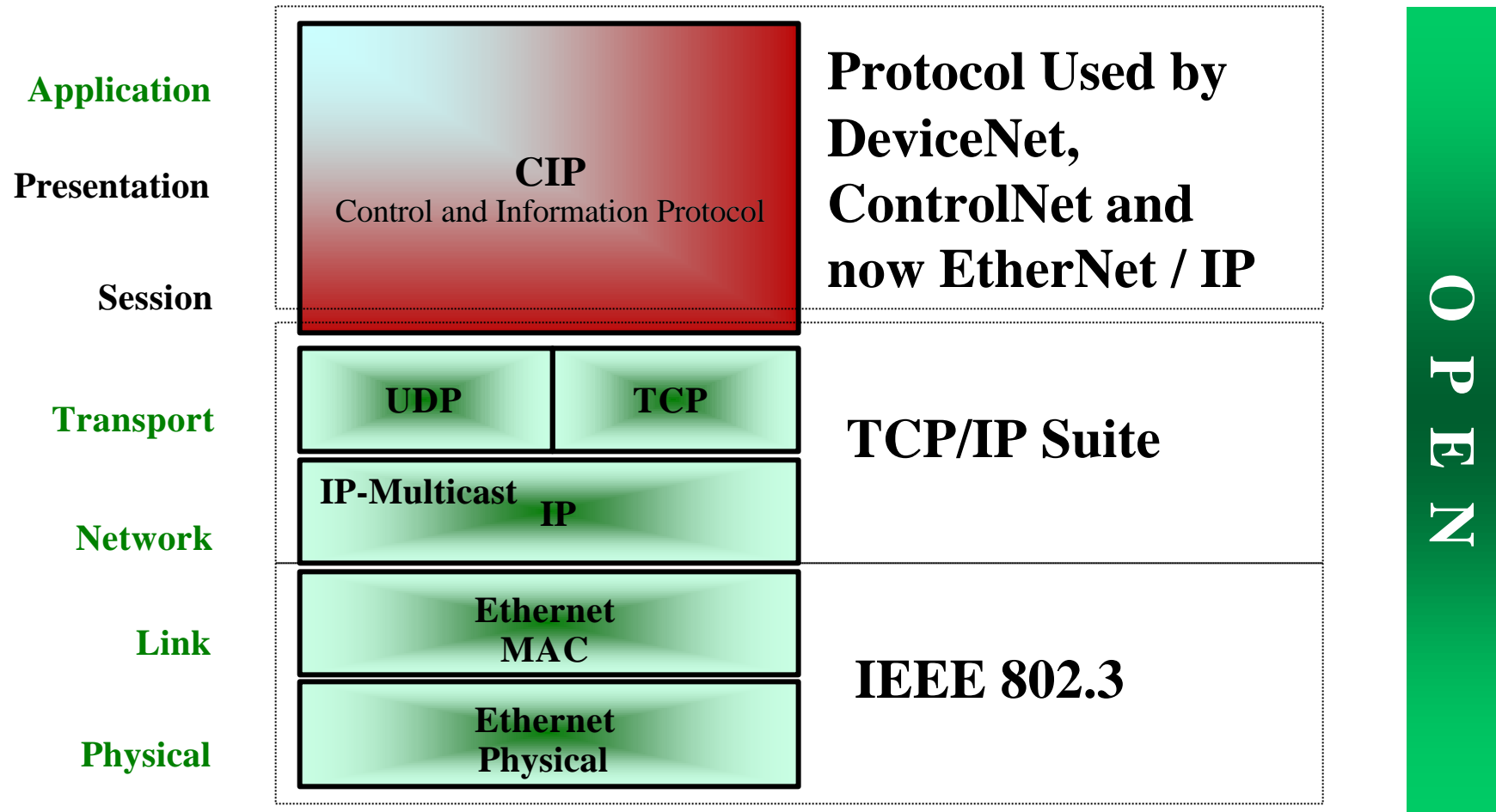
Robot
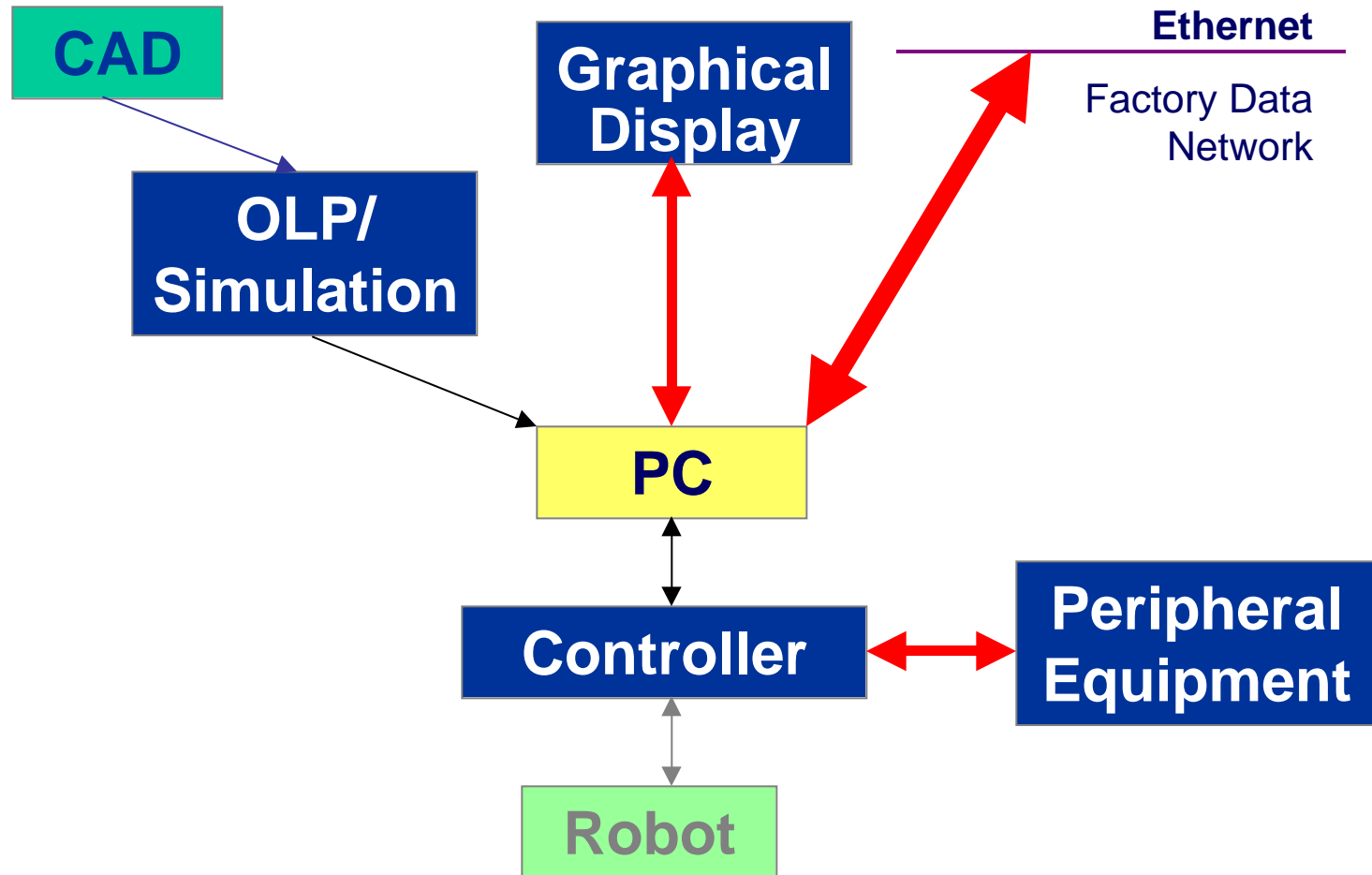
Factory Data Networks

- GM has up to 6 or 7 different networks
- Three level data networks:
  - Ethernet
  - Controlnet
  - Devicenet
- Moving to two
  - Switched ethernet
  - Devicenet

Switched Ethernet

High Speed Backbone

Switch

Switch

10 Mbit Ethernet

EtherNet / IP !!!

Application		**Protocol Used by DeviceNet, ControlNet and now EtherNet / IP**
Presentation	**CIP** Control and Information Protocol	
Session		
Transport	UDP TCP	**TCP/IP Suite**
Network	IP-Multicast IP	
Link	Ethernet MAC	**IEEE 802.3**
Physical	Ethernet Physical	

O P E N

**Control and Information Protocol (CIP) -
An Object Orientated Application Layer Protocol**

GM "First Wave" Proposal for Robot Interface Standards

Leverage the Existence and Volumes of Marketplace Technology Standards

		Current	Emerging
Communications	Media	Copper - CAT 5 / CAT 6	CAT 6
		Fiber Single & Multi Mode	Fiber Single & Multi Mode
	Communications Protocol	TCP - RFC 793	TCP - RFC 1122
		IPv4 - RFC 791,1122,1812	IPv6,IPSEC RCF 1825-7
	Event Management	SNMP - RFC 1901-10	SNMP w/ MIB II - RFC 1213,1157
Operator Presentation	Graphics	Browser (IE, Netscape)	Browser (IE, Netscape)
	Character	Browser	Browser
Network Services	Setting Common Time	NTP - RFC 997	NTP - RFC 1119
	Network Management.	SNMP	SNMP w/ MIB II
	Data Representation	XML	XML,XSL,ISO 8879 & W3C XML v1
	Development	JAVA / C++ / GNU	JAVA / GNU

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Action Plan

- Gather potential standards

- Collect field experience

- Prioritize

- Develop implementation plans

- Launch testing

Future

- Peripheral Interface Standards

- Graphical Display Interface Standards